THE EFFECTS OF EXTINCTION, NONCONTINGENT REINFORCEMENT, AND DIFFERENTIAL REINFORCEMENT OF OTHER BEHAVIOR AS CONTROL PROCEDURES

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Several techniques have been used in applied research as controls for the introduction of a reinforcement contingency, including extinction, noncontingent reinforcement (NCR), and differential reinforcement of other behavior (DRO). Little research, however, has examined the relative strengths and limitations of these "reversal" controls. We compared the effects of extinction with those of NCR and DRO in both multielement and reversal designs, with respect to (a) rate and amount of response decrement, (b) rate of response recovery following reintroduction of reinforcement, and (c) any positive or negative side effects associated with transitions. Results indicated that extinction generally produced the most consistent and rapid reversal effects, with few observed negative side effects.

DESCRIPTORS: differential reinforcement of other behavior, experimental design, extinction, noncontingent reinforcement, reinforcement control procedures

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A defining feature of applied behavior analysis is the use of single-subject experimental designs, in which a participant is exposed to at least one experimental condition involving the introduction of the independent variable and to at least one control condition in which the independent variable is absent. When the independent variable involves the introduction of a reinforcement contingency, the appropriate control condition involves its removal, and a functional relation (i.e., experimental control) is demonstrated if rates of behavior are consistently higher when the reinforcement contingency is present than when it is absent (Baer, Wolf, & Risley, 1968).

The purpose of the current investigation was to evaluate the effects of three control procedures that have been used in applied research on the effects of positive reinforcement. The procedure used most commonly is the traditional extinction condition, in which reinforcers are simply no longer delivered (e.g., Craig & Holland, 1970; Green, Reid, Canipe, & Gardner, 1991). An alternative to the extinction procedure is the

noncontingent reinforcement (NCR) control, in which the contingency is eliminated by delivering reinforcers according to a response-independent schedule (e.g., Hart, Reynolds, Baer, Brawley, & Harris, 1968; Lattal, 1969). Finally, differential-reinforcement-of-other-behavior (DRO) schedules "reverse" the contingency by delivering reinforcers contingent on the absence of the target response (e.g., Baer, Peterson, & Sherman, 1967; Reynolds & Risley, 1968).

Rescorla (1967) suggested that the most convincing demonstration of experimental control is achieved when the control condition contains all features of the experimental condition, while only the independent variable is eliminated. The typical positive reinforcement arrangement involves two key features: A stimulus is presented, and a contingency is arranged between the occurrence of a response and the delivery of the stimulus. Thus, demonstration of a functional relation between the reinforcement contingency and behavior requires isolating not only the effects of reinforcement from those of other potentially confounding variables but also the effects of the contingency from those of mere stimulus presentation.

The extinction control eliminates stimulus presentations as well as the contingency between the response and stimulus delivery. As a result, extinction does not isolate the effects of the reinforcement contingency from those of mere stimulus presentation. For example, Rheingold, Gewirtz, and Ross (1959) compared levels of infant vocalization under a social reinforcement condition with those under an extinction control condition in which no social stimulation (e.g., smiling or physical interaction) was presented. The authors noted that the extinction control limited the extent to which increases in infant vocalization observed in the reinforcement condition could be attributed to the reinforcement contingency. That is, because no social stimulation was presented during extinction, the experimental arrangement did not rule out the possibility that infant vocalizations were elicited by the mere presentation of social stimulation.

A more convincing control requires a condition in which the contingency is eliminated but the stimulus continues to be presented. Thus, the NCR control condition is considered by some researchers to be the most methodologically appropriate procedure for demonstrating the effects of positive reinforcement (Rescorla & Skucy, 1969). Buell, Stoddard, Harris, and Baer (1968) used an NCR control to evaluate the effects of social reinforcement on a child's use of playground equipment. During the reinforcement condition, teachers provided continuous attention whenever the child used the equipment. Behavior in this condition was compared with that observed during NCR sessions in which teacher attention was provided independent of whether the child used the equipment. Higher levels of equipment use were observed in the reinforcement condition, demonstrating that the reinforcement contingency rather than the mere delivery of the reinforcer was responsible for the behavior change.

The DRO control also involves the continued presentation of stimuli delivered during the reinforcement condition, and therefore might be considered more methodologically appropriate than the extinction control. However, a limitation of the DRO control is that the original reinforcement contingency is replaced with a new contingency. During the reinforcement condition, there is an increased probability of reinforcement given a response, whereas in the DRO control, there is a zero probability of reinforcement given a response and a corresponding increased probability of reinforcement given the absence of a response. Because the DRO control introduces a new contingency that was not present in the experimental condition, DRO might be con-

sidered less appropriate than the NCR control as an alternative to extinction.

The DRO control was used in a study by Poulson (1983) that evaluated the effects of social reinforcement on infant vocalizations. During the reinforcement condition, infant vocalization resulted in social stimulation (e.g., talking to or touching the infant) according to a continuous reinforcement schedule. Levels of vocalization in this condition were compared with those observed in a DRO condition in which social stimulation was presented every 2 s but was delayed for 4 s when vocalizations occurred. Higher levels of vocalization were observed in the reinforcement condition relative to the DRO control condition, suggesting that infant vocalizations were sensitive to the reinforcement contingency. This study represented a methodological improvement over previous research on the effects of social reinforcement on infant vocalization that used the extinction control and failed to rule out the alternative interpretation that infant vocal behavior was elicited by social stimulation (e.g., Rheingold et al., 1959; Todd & Palmer, 1968).

Aside from the methodological issues described above, practical issues may influence decisions to select a control condition. For example, researchers should consider the extent to which experimental control can be demonstrated efficiently (i.e., quickly), which is achieved when the introduction of a control condition results in a rapid and large decrease in the target response. Results of the few studies in which extinction was compared with NCR or DRO have shown that extinction produced the most rapid and largest reductions in the target response. For example, Uhl and Garcia (1969) found that extinction resulted in more rapid reductions in responding than did DRO. Similarly, Rescorla and Skucy (1969) compared the effects of an extinction condition with those obtained with both NCR and DRO schedules.

Results indicated that all three of the procedures resulted in substantial reductions in the target response; however, the extinction condition produced the largest and most rapid effects.

Persistence of responding during NCR conditions has been observed in a number of investigations (e.g., Herrnstein, 1966; Neuringer, 1970; Skinner, 1948) and has often been attributed to the accidental reinforcement of the target response. Therefore, although NCR is the most methodologically advantageous control procedure, a practical limitation is the possibility of response maintenance due to adventitious reinforcement. In this respect, DRO may offer a practical advantage over the NCR control: Because reinforcers are delivered contingent on the absence of the target response during DRO, there is no opportunity for accidental reinforcement. Goetz, Holmberg, and LeBlanc (1975) compared DRO and NCR as control procedures while attempting to increase a young girl's compliance. Compliance with requests was followed by physical proximity of the teacher during reinforcement and was compared with compliance during two control conditions. In the NCR condition, teacher proximity was presented contingent on both compliance and noncompliance; in the DRO condition, teacher proximity was presented contingent on noncompliance. Results indicated that DRO produced more rapid and larger decrements in compliance than did NCR. It is important to note that data collected on implementation of the independent variable suggested that teachers were actually reinforcing compliance during the NCR condition; therefore, the conclusions that can be drawn from this study are limited.

In addition to the speed and amount of response *decrement* produced by a reinforcement control procedure, the speed of response *recovery* when reinforcement is reinstated also contributes to an efficient dem-

onstration of control. Goetz et al. (1975) examined response recovery under reinforcement immediately following exposure to NCR and DRO control conditions and found no difference in the speed of recovery; however, other studies have not addressed this issue.

Finally, a control procedure may be deemed undesirable if it produces negative side effects. extinction has been associated with problems such as response bursting or emotional responding (see Lerman & Iwata, 1996, for a review), and similar negative side effects have been reported when DRO has been used to reduce problem behavior (Cowdery, Iwata, & Pace, 1990). By contrast, NCR has been reported to minimize the presence of side effects (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993; Vollmer et al., 1998). However, because the occurrence of these effects has rarely been recorded, additional research is needed to determine their prevalence. For example, Lerman and Iwata (1995) examined 113 data sets and found that extinction bursts occurred in 24% of cases, suggesting that this negative side effect may be less common than previously assumed.

In an attempt to identify the relative strengths and limitations of reinforcement control procedures along a number of dimensions, we directly compared extinction with DRO and NCR. Data were collected to allow within-subject comparisons with respect to (a) rate and amount of response decrement, (b) rate of response recovery during subsequent reinforcement conditions, and (c) observed side effects (e.g., emotional responding, aggression, extinction bursts).

METHOD

Participants and Setting

Participants were 9 adults with developmental disabilities who attended a workshop program. These individuals had been re-

Table 1
Participant Characteristics

Name	Age (years)	Diagnosis and sensory impairments[a]
Kal	47	Profound MR,visual impairment
Sven	45	Profound MR, autism
Brad	36	Mild MR
Phyllis	30	Profound MR
Amy	39	Severe MR, seizure disorder
Peg	50	Moderate MR, Prader-Willi syndrome
Larry	34	Moderate MR, seizure disorder, hearing impairment
Julie	38	Severe MR, Down syndrome
Lynn	42	Mild MR, seizure disorder

[a] MR = mental retardation.

ferred by a staff psychologist for preference and reinforcer assessments, the results of which would be incorporated into programs designed to reduce problem behavior (e.g., skin picking, off-task behavior) or increase appropriate behavior (e.g., leisure-item manipulation, communication). Participant information is presented in Table 1. Sessions were conducted in the participants' workshop or group home in quiet areas that contained tables, chairs, and materials needed to conduct sessions (see below). Sessions lasted 10 min and were conducted two to four times per day, 4 to 5 days per week.

Response Measurement and Interobserver Agreement

Target behaviors were chosen for participants on an individual basis. In some cases, target responses were related to communicative (e.g., Kal and Sven) or vocational (e.g., Lynn) goals. In other cases (e.g., Brad and Phyllis), experimenters chose simple, low-effort responses with which the participants had little history. Target responses included the following: emitting the manual (American sign language) sign for "please" (Kal), pressing a button on a voice-output device that played the message "snack please" (Sven), toe touching (Brad), micro-

switch pressing (Phyllis, Peg, and Julie), stair stepping (Amy and Larry), and silverware sorting (Lynn). An observer recorded the frequency of the target behavior on a laptop computer using the !Observe program. In addition, the observer recorded the frequency of the following events. *Reinforcer delivery* was recorded each time the therapist placed an edible item on the participant's plate or placed a token into the designated container (Peg only). A *request* was recorded any time a participant verbally asked for (i.e., vocally or through manual sign) the reinforcer, pointed at it, or attempted to grab it. An *attempt to leave* the session was recorded each time a participant verbally requested to leave the area or attempted to leave the area without permission. A *negative vocalization* was recorded when a participant whined or complained about sessions. *Problem behavior* was recorded when a participant engaged in self-injury (e.g., head hitting, skin picking), aggression (hitting, kicking, scratching, or biting therapist), or disruptive behavior (throwing or attempting to destroy materials). Requests, attempts to leave, negative vocalizations, and problem behaviors were rarely observed. Therefore, data on requests are reported for Kal only.

Interobserver agreement was assessed by having a second observer simultaneously but independently record data during a minimum of 30% of sessions for each participant (range, 30.3% to 52%). Agreement percentages were calculated by partitioning session time into 10-s intervals and comparing observers' records on an interval-by-interval basis. The smaller number of responses in each interval was divided by the larger number of responses; these fractions were then averaged across intervals and multiplied by 100%. Mean percentage agreement was above 90% for all measures and all participants.

Reinforcer Selection

Prior to the start of the study, preference assessments, based on procedures described by DeLeon and Iwata (1996), were conducted with each participant. Seven items were placed in an array in front of the participant, who was then allowed to select and consume one item. The selected item was then removed from the array and the participant was allowed to select from the remaining items. This process continued until all items were selected or 30 s passed with no selection. The assessment was repeated a minimum of five times, after which selection percentages were calculated for each item by dividing the number of times that the item was selected by the number of trials on which the item was available and multiplying the quotient by 100%. Assessments involved the presentation of edible items for all participants except for Peg, who participated in a leisure-activity assessment due to dietary restrictions. For Peg, the five items or activities (sewing, painting, magazines, art, and stickers) identified through the preference assessment as most highly preferred were chosen for use in the study. For all other participants, an item was chosen from among the items ranked in the top three. Stimuli selected for each participant were mint patties (Kal), candy-coated chocolate pieces (Sven, Brad, Phyllis, and Larry), jelly beans (Brad), pretzels (Amy), pieces of fig bar (Julie), and cereal (Lynn).

Results of the preference assessment and subsequent reinforcer assessment were made available to behavior analysts who were responsible for writing and implementing treatment programs for each of the participants. Results were incorporated in various ways, depending on the needs of the individual. For example, it was recommended that Peg have frequent access to her preferred activities to increase her level of engagement and decrease skin picking, and Sven's results were used to develop a program to teach him to fasten his seat belt independently.

Procedure

To ensure that the target response came into contact with the consequences for responding associated with each experimental condition, two physical prompts to perform the response were delivered prior to each session. The designated consequences for responding were delivered following the prompted response. Specifically, prior to sessions (i.e., prior to the start of data collection) in the baseline, extinction, NCR, and DRO conditions, the therapist physically prompted the target response and then provided no consequences. Prior to sessions in the reinforcement condition, the therapist physically prompted the target response and then delivered the reinforcer.

Baseline. During baseline sessions, task materials were present and the target response resulted in no programmed consequences.

Reinforcement. During reinforcement sessions, a small piece of the edible item or one token was delivered contingent on the target response according to a fixed-ratio (FR) 1 schedule. Peg was allowed to exchange tokens for access to preferred items or activities immediately following each session in which reinforcers were delivered. Additional prompts to perform the target response were provided during initial FR 1 sessions conducted with Sven and Phyllis. Verbal and model prompts were provided every 30 s if these participants had not engaged in the target response within the last 30 s. Prompts were discontinued after five and three sessions for Sven and Phyllis, respectively. No prompts were delivered during subsequent FR 1 sessions.

Extinction. During extinction sessions, task materials were present and the target response resulted in no programmed consequences (the edible items or tokens were absent). An extinction-with-food condition was implemented with Lynn only. In this condition, Lynn's preferred edible item was present throughout the session but was never delivered.

DRO. During DRO sessions, the edible item was delivered contingent on the absence of the target response during intervals of a specified length, which was equal to the mean interresponse time (IRT) from the last four sessions of the previous reinforcement condition. The DRO interval was reset each time a target response occurred.

NCR. During NCR sessions, the edible item or token was delivered according to a fixed-time (FT) schedule, which was equal to the mean IRT from the last four sessions of the previous reinforcement condition.

Experimental Design

Following baseline, reinforcement and control conditions were implemented in reversal designs. All participants were exposed to the extinction control condition. Kal, Sven, Brad, Phyllis, and Amy were exposed to extinction and DRO; Peg, Larry, Julie, Brad, and Lynn were exposed to extinction and NCR. Brad was exposed initially to extinction and DRO. At the conclusion of this study, he asked if he could continue to participate; therefore, he was also exposed to extinction and NCR. Comparisons between control conditions were made using first multielement and then reversal designs for each participant. The multielement design was conducted first to provide the most direct comparison of the two control conditions prior to any extensive experimental history with either of these conditions. The reversal design allowed the assessment of speed of response recovery following exposure to individual control conditions. Each condition was continued until researchers determined, using visual inspection of the data, that four consecutive stable points were obtained. When two conditions were compared in a multielement design, conditions

were conducted until stability was achieved in both conditions.

RESULTS

Extinction and DRO Comparisons

The top panel of Figure 1 shows the number of target responses per minute exhibited by Kal. No responses occurred during baseline; however, responding increased and was maintained at a high rate when reinforcement was delivered according to the FR 1 schedule. During the multielement comparison of the DRO and extinction control conditions, extinction resulted in an immediate and sustained reduction in the target response to near-zero levels. DRO also resulted in an immediate, but smaller, decrease in the target response and a gradual reduction to near-zero levels. High rates of the target response were recovered in the subsequent FR 1 phase. Extinction and DRO were then compared in a reversal design. Kal's responding again decreased immediately to zero under extinction but recovered immediately in the subsequent FR 1 condition. An immediate but smaller decrease in the target response was observed under DRO, followed by a gradual decrease in responding to near zero. Responding recovered quickly in the final FR 1 condition.

The middle panel of Figure 1 shows the number of requests per minute displayed by Kal, which were recorded when he pointed to his mouth and said "eee," moved his plate toward the therapist, or attempted to reach for the edible item. These responses rarely occurred during the baseline, FR 1, and extinction conditions. By contrast, Kal exhibited high rates of requesting during both DRO conditions. Requests generally increased during the first few DRO sessions, then gradually decreased to near-zero levels as the phase continued. It appeared that these responses were accidentally reinforced during initial sessions of the DRO phases (i.e., reinforcement was delivered for the absence of the target response but occasionally followed requests); however, requests eventually decreased, presumably due to the absence of a programmed contingency of reinforcement for these responses.

Sven's target response (Figure 1, bottom panel) never occurred during baseline but gradually increased to high rates during the first FR 1 phase (prompted responses are not included on the figure). During the multielement comparison of DRO and extinction, responding decreased to low rates in the extinction condition, although zero levels of the response were not achieved. Responding in the DRO condition did not decrease consistently; instead, it was variable and sometimes overlapped with the FR 1 condition. Following a return to the FR 1 condition, during which responding increased, extinction and DRO were compared in a reversal design. Extinction resulted in a substantial decrease in responding followed by rapid recovery of the response in the subsequent FR 1 condition. DRO also resulted in a substantial decrease in responding, but with more variable responding than was observed in the extinction condition. High rates of responding were not recovered until the third session of the final FR 1 condition.

The top panel of Figure 2 shows the results of Brad's extinction and DRO comparison. Brad never performed the target response during baseline or during any of the extinction sessions but showed high and stable rates during each of the FR 1 conditions. Responding occurred during only the first session of each DRO condition.

Phyllis (Figure 2) exhibited very low rates of responding during baseline but relatively high and stable rates when the reinforcement contingency was introduced (prompted responses are not included on the figure). When extinction and DRO were compared in the multielement design, both procedures quickly reduced responding to low levels, al-
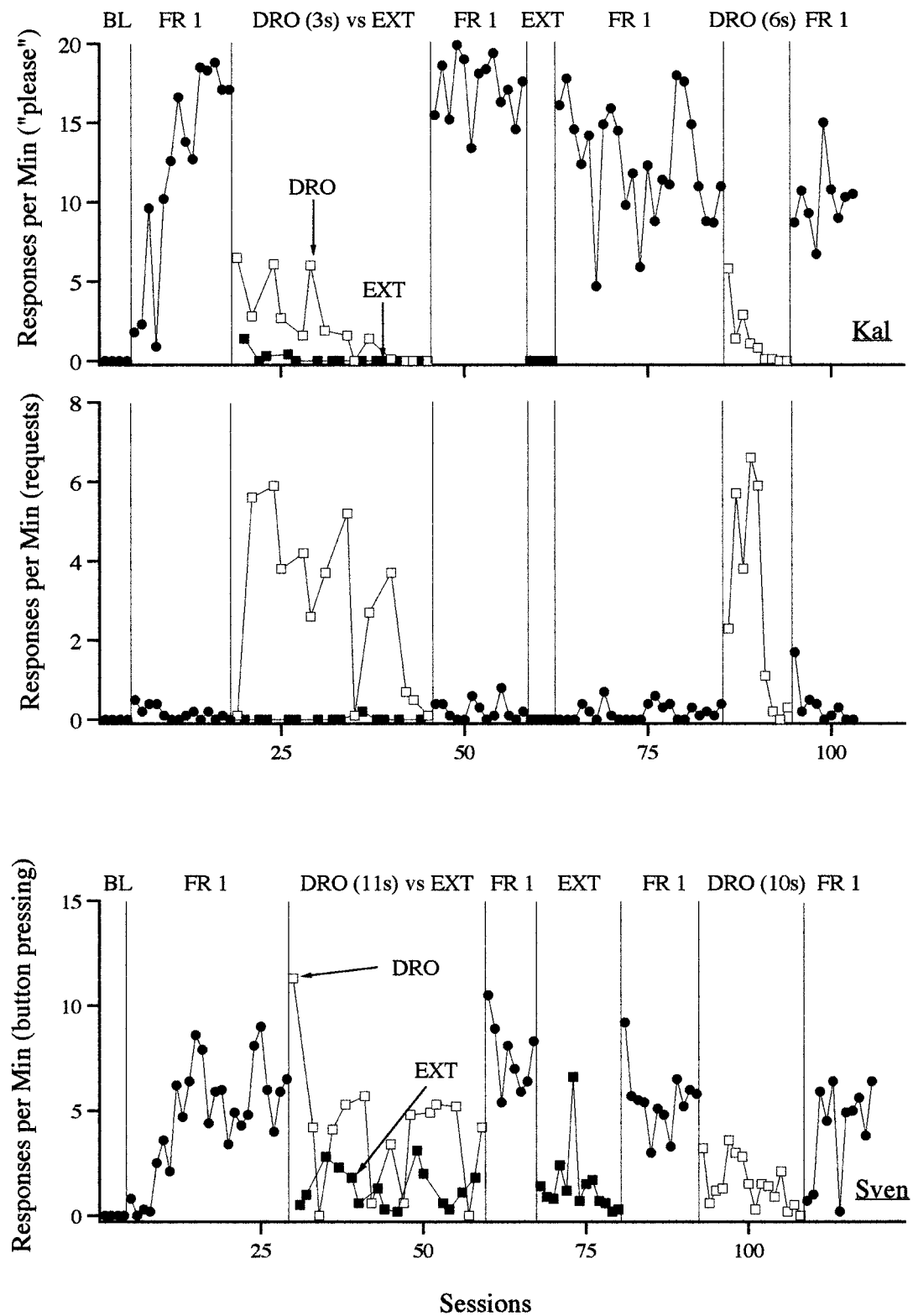
Figure 1.   Kal's target responses (top panel) and requests (middle panel) per minute, and Sven's target responses per minute (bottom panel), during extinction and DRO comparisons.
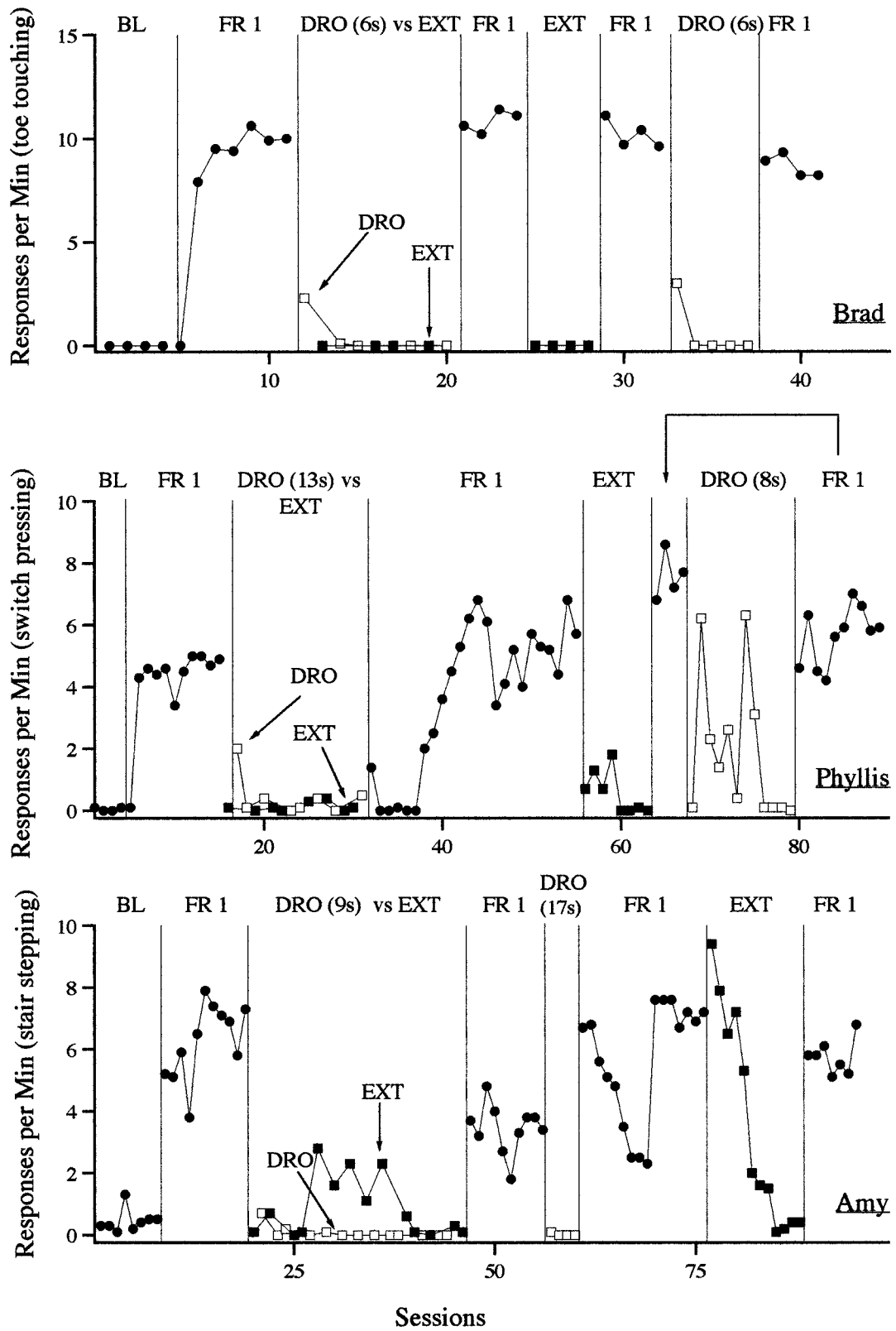
Figure 2. Target responses per minute for Brad, Phyllis, and Amy during extinction and DRO comparisons.

though fewer responses were observed in the extinction condition. Responding recovered slowly during FR 1 following the multielement phase but eventually reached stability. When extinction was introduced, responding decreased to near-zero rates after four sessions; when FR 1 was reintroduced, responding recovered quickly. When DRO was introduced, variable rates of responding occurred for approximately eight sessions before decreasing to near zero. Behavior recovered quickly during the final FR 1 condition.

Amy (Figure 2) responded at a low rate during baseline but at a high rate in the FR 1 condition. In the initial sessions of the multielement comparison, responding decreased to a very low rate in the DRO condition and to a low but more variable rate in the extinction condition. Responding increased to a high and steady rate during the subsequent FR 1 phase. During the reversal comparison, responding decreased immediately to near zero during DRO and recovered quickly in the subsequent FR 1 condition. The introduction of extinction resulted in an initial increase in responding, followed by a reduction to near zero. Responding recovered quickly in the final FR 1 phase.

Extinction and NCR Comparisons

Peg (Figure 3) never engaged in the target response during baseline but displayed high rates of responding (except for one session) when reinforcement was introduced. When extinction and NCR were compared in a multielement design, neither produced a consistent decrease in responding; behavior remained variable in both conditions as well as during the subsequent FR 1 condition. When extinction was evaluated in the reversal design, Peg's responding remained variable for 12 sessions before decreasing to zero. Her behavior recovered quickly during the subsequent FR 1 phase. When NCR was in-

troduced, responding again remained variable (for 13 sessions) before decreasing to zero. High and stable rates of behavior were recovered relatively slowly during FR 1 after exposure to the NCR condition.

Larry (Figure 3) emitted no responses during baseline or any of the extinction or NCR conditions. However, he engaged in the target response at high and consistent rates during each exposure to the FR 1 condition.

Julie (Figure 4) exhibited low rates of the target response during baseline but high rates when reinforcement was introduced. During the multielement comparison, her responding immediately decreased to near zero in the extinction condition but decreased more slowly and was maintained at moderate rates in the NCR condition. Julie's responding recovered quickly in the FR 1 condition, decreased immediately to zero in the extinction condition, and again recovered quickly during the brief FR 1 condition. A gradual and moderate decrease in responding was observed in the NCR condition, followed by a gradual recovery in the final FR 1 condition.

Brad (Figure 4) never performed the target response during baseline or any of the extinction sessions, and he displayed consistently high rates of responding during all FR 1 sessions. When NCR was introduced in the multielement comparison, responding decreased but was maintained at moderate rates. When NCR was introduced again in the reversal design, responding was maintained at high but variable rates.

Lynn (Figure 4) did not perform the target response during baseline, but her responding increased to high and stable rates during the FR 1 condition. When extinction and NCR were compared in a multielement design, her responding in the extinction condition decreased to zero after five sessions but persisted in the NCR condition at high and stable rates. Responding recovered after
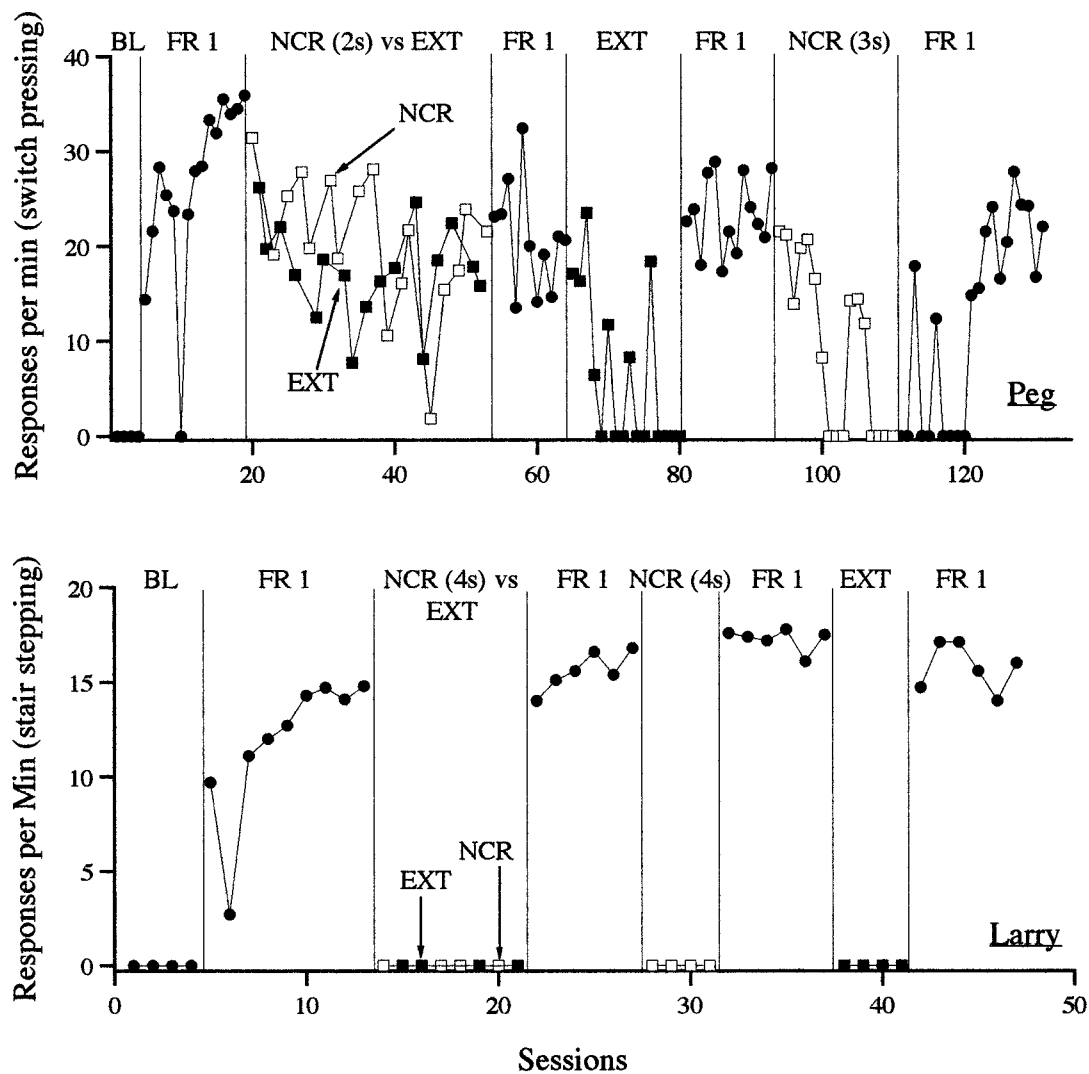
Figure 3.   Peg's and Larry's target responses per minute during extinction and NCR comparisons.

four sessions during the subsequent FR 1 phase. Lynn's responding decreased to zero by the second session when extinction was implemented in the reversal design and recovered immediately during the subsequent FR 1 phase. When NCR was implemented, responding again was maintained at high and stable rates. In an attempt to identify the factors that contributed to response maintenance under NCR, we added further manipulations. The first manipulation was conducted to determine whether responding had been accidentally reinforced during the

NCR control condition due to unprogrammed contiguity between the target and the delivery of reinforcement. A DRO condition was implemented in which the reinforcement was delivered contingent on the absence of responding (the DRO interval was equal to the FT interval during the NCR condition). Lynn's responding persisted at high rates in the DRO condition; as a result, the rate of reinforcer delivery during the DRO condition was extremely low (0.6 per minute) relative to reinforcement rates during the previous FR 1 (7.2 per minute)
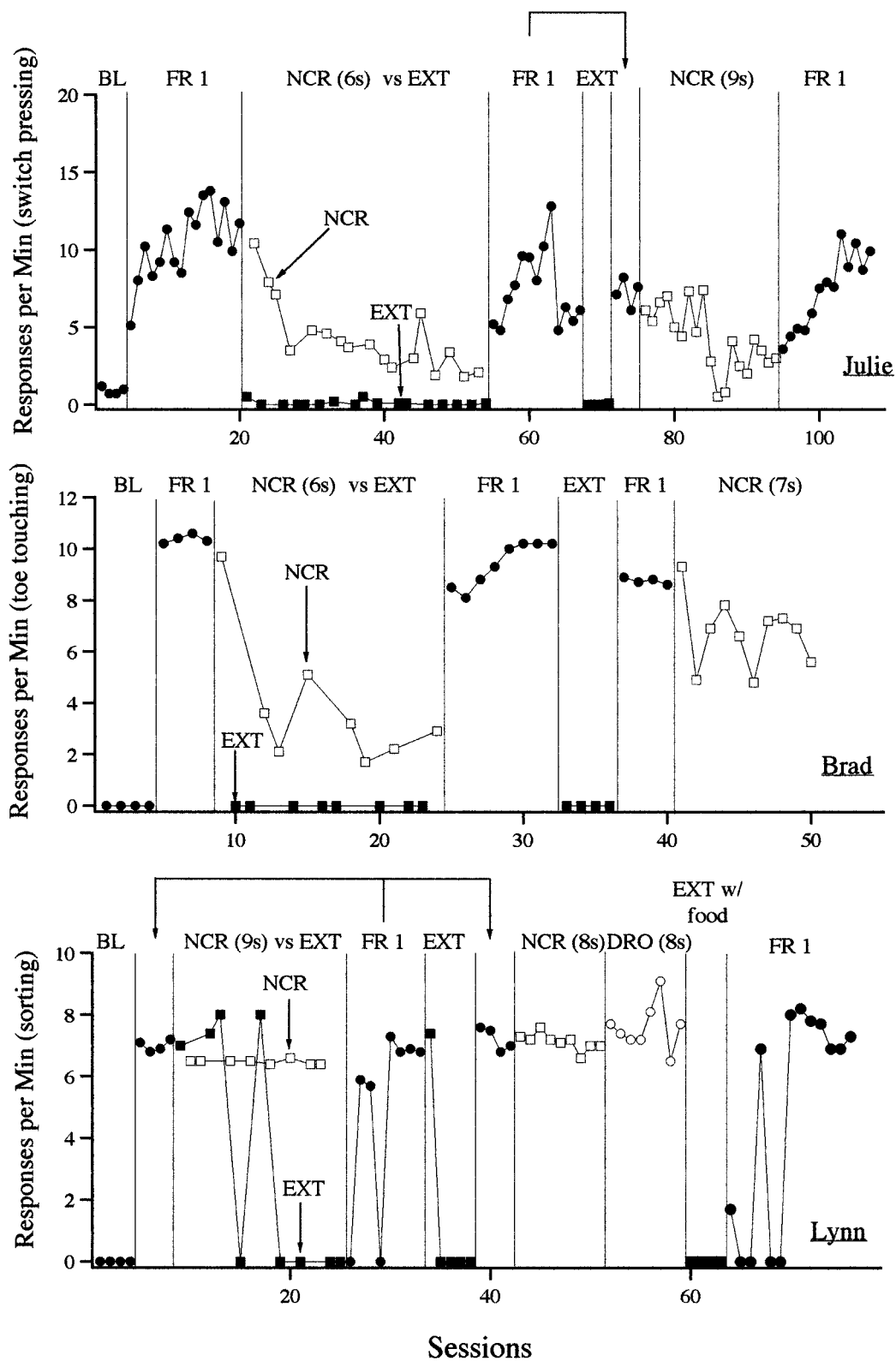
Figure 4.   Julie's, Brad's, and Lynn's target responses per minute during extinction and NCR comparisons.

and NCR (7.3 per minute) conditions. Persistence of responding in the DRO condition suggested that accidental reinforcement was not responsible for maintenance during NCR.

A second manipulation was implemented to determine whether responding was under stimulus control of the presence of the reinforcer. Responding occurred at low rates during conditions in which the reinforcer was absent (baseline and extinction) but occurred at high rates during conditions in which the reinforcer was present (FR 1, NCR, and DRO). Thus, it was possible that the mere presence of the reinforcer occasioned responding. We therefore implemented an extinction condition in which the food reinforcer was in view but was never delivered. Lynn never emitted the target response during this condition, suggesting that her responding was not occasioned by the mere presence of the reinforcer. These results suggested that Lynn's responding had come under stimulus control of reinforcer delivery rather than the presence of the reinforcer per se. Finally, her responding recovered slowly during the last FR 1 condition.

DISCUSSION

We compared an extinction control with NCR and DRO controls and found that extinction produced the most rapid and complete reversal effects. These results are consistent with those of previous studies in which extinction was compared with either NCR or DRO (e.g., Rescorla & Skucy, 1969; Uhl & Garcia, 1969). The extinction condition is the most commonly used control in applied research (e.g., DeLeon & Iwata, 1996; Freeland & Noell, 1999; Hagopian & Thompson, 1999; Lerman, Kelley, Vorndran, Kuhn, & LaRue, 2002; Northup, George, Jones, Broussard, & Vollmer, 1996), and our findings support the continuation of this practice.

NCR failed to produce a substantial reduction in responding in 2 of 5 participants (Lynn and Brad), and produced consistent but small decreases in responding in a 3rd participant (Julie). These results are consistent with those of other studies in which response maintenance was observed during NCR conditions (e.g., Dozier et al., 2001; Konarski, Johnson, Crowell, & Whitman, 1980; Osborne, 1969). The persistence of responding under NCR has often been attributed to accidental reinforcement, which may occur when stimuli are delivered contiguous with, although not contingent on, responding.

It is possible that response maintenance observed with some participants during NCR was a result of accidental reinforcement; however, we eliminated the possibility of accidental reinforcement during NCR by also conducting a DRO condition with 1 participant (Lynn). Surprisingly, we observed that Lynn's behavior also persisted in the DRO condition, suggesting that the reinforcer (absent during extinction but present during NCR and DRO) exerted stimulus control over responding. To examine this possibility, we conducted an extinction-with-food condition in which the reinforcer was present but was not delivered at any time during the session. Lynn never engaged in the target response during this condition, suggesting that the delivery of the reinforcer (and not its mere presence) served as a discriminative stimulus that occasioned responding. Results obtained with Lynn were consistent with those reported by Uhl and Garcia (1969), who examined factors that contributed to the persistence of responding during DRO. They attributed this phenomenon to the strengthening of a behavioral chain during contingent reinforcement conditions, in which the delivery of a reinforcer becomes discriminative for responding.

Koegel and Rincover (1977) also found evidence of the discriminative properties of

reinforcer delivery. During the training phase of their study, children received edible reinforcers and praise for following a model or verbal instruction to complete simple tasks. Two of the children then were exposed to a condition in which reinforcers were delivered after 10 consecutive incorrect trials (i.e., DRO). Results showed that correct responses increased substantially immediately after the initial reinforcer deliveries, although this effect diminished across repeated reinforcer deliveries. Taken together, the results of these studies suggest that the presentation of reinforcers may exert stimulus control over responding. Thus, some cases of response persistence during NCR that have previously been attributed to accidental reinforcement may have been a result of stimulus control by reinforcer presentation.

Although data from the extinction-with-food condition conducted with Lynn indicated that the presence of the reinforcer did not occasion her responding, it appears that the presence or absence of the reinforcer exerted some control over the responding of other participants. For example, during Brad's extinction and DRO comparison, he never performed the target response in any of the extinction sessions, whereas he engaged in the target response in the first DRO session of each phase. Some of the responses in these initial DRO sessions occurred before the first reinforcer delivery, suggesting that the presence (and not the delivery) of the reinforcer was sufficient to occasion responding. These results suggest that the absence of the reinforcer during the extinction conditions may have contributed substantially to the efficiency of the procedure. In the present study, we opted to remove the reinforcer from the extinction condition to capitalize on this practical advantage of the extinction control; it is possible, however, that reductions in responding during extinction would have occurred more slowly had the reinforcer been present. Future research could deter-

mine the effects of reinforcer presence by comparing extinction conditions in which the reinforcer is present or absent.

It is important to note that any differences in responding among control conditions cannot be attributed to presession prompts because these prompts were identical across the three control conditions. That is, prior to each extinction, DRO, and NCR session, the therapist physically guided the participant to perform the target response and provided no consequence. Presession prompts were included to ensure that the participants' behavior came into contact with the consequence for responding prior to each session and apparently affected Larry's performance dramatically. Because he never performed the target response during extinction or NCR sessions, zero levels of responding obtained in these conditions can only be attributed to exposure to contingencies during presession prompts. Judging from his performance, it seems likely that Larry's responding would have decreased rapidly in both conditions (extinction and NCR) even if presession prompts were not delivered, because two unreinforced responses (during presession prompting) were sufficient to eliminate his responding throughout the session.

We examined data from FR 1 conditions that were introduced following exposure to each of the three control conditions during the reversal comparison and found that high levels of the target response were recovered within the first session after exposure to extinction in all 10 cases. Slower recovery was observed following exposure to NCR with 2 participants (Peg and Julie) and to DRO with 1 participant (Sven). Thus, with respect to speed of recovery following exposure to the control conditions, the extinction condition was again found to be most efficient.

The introduction of extinction resulted in a response burst in only 1 participant (Amy) out of 10. These results are consistent with

those reported by Lerman and Iwata (1995) and by Lerman, Iwata, and Wallace (1999) in suggesting that extinction bursts may be less common than previously assumed. It is important to note, however, that the generality of this finding is limited because target responses were exposed to very brief histories of reinforcement that was delivered according to very dense (FR 1) schedules. A response burst was also observed in the first DRO session conducted with 1 participant (Sven). However, this session might be considered functionally equivalent to an extinction session because high rates of responding resulted in a very low rate of reinforcement (0.7 per minute) according to the DRO schedule. By contrast, a high rate of reinforcement was delivered in all NCR sessions, and response bursts were never observed. High rates of reinforcement delivered during NCR may have eliminated the establishing operation for responding (deprivation), thus decreasing the probability of response bursts (Vollmer et al., 1998). Although bursting may be less problematic when the target response is an appropriate response (e.g., work performance) rather than an inappropriate one (e.g., self-injury), it is, nevertheless, a negative effect that may necessitate lengthier exposure to control conditions.

In addition to evaluating the direct effects of control conditions on the target response, we also wanted to determine the extent to which each of these conditions produced changes in nontarget responses. We recorded a number of categories of behavior for each participant, but negative side effects such as negative vocalizations, attempts to leave the session, and problem behavior were rarely observed and were unrelated to any of the control conditions.

Although nontarget responses might be expected to increase under DRO schedules, few researchers have actually recorded "other" responses when evaluating DRO (Poling & Ryan, 1982). A notable exception is a study by Zeiler (1970), in which 6 preschool children were taught to press two concurrently available levers to produce pieces of candy. After this history of reinforcement was established, a DRO contingency was arranged for responses on the right lever, whereas responses on the left lever had no effect (extinction). Results showed that 4 of the 6 children continued to respond on the left lever at very high rates, suggesting that, in some cases, "other" responses may be reinforced when DRO is implemented. We observed a similar effect with one participant. Kal displayed requests for the reinforcer (e.g., pointing to the reinforcer, signing "eat," moving his plate toward the therapist) at high rates during many of the DRO sessions, but he rarely engaged in these behaviors during the other experimental conditions. These responses increased during the beginning of each DRO condition and gradually decreased across DRO sessions. Thus, it is possible that requests for the reinforcer were accidentally reinforced during DRO. However, given that there was no programmed contingency for these responses, it is not surprising that this effect was temporary.

To summarize, the extinction control produced the most consistent, rapid, and largest decreases in the target response in most cases. Thus, although NCR may be the most methodologically advantageous procedure, extinction may be most preferred from a practical standpoint. This presents a difficulty for applied researchers who must balance methodological and practical considerations. However, research that clearly delineates the effects of various control procedures should contribute to the applied researcher's ability to weigh these concerns effectively. For example, if an experiment is to take place during a limited time period, the researcher may choose to sacrifice some methodological rigor to increase the efficien-

cy of the experiment by selecting extinction over the NCR control.

Finally, we must emphasize the fact that our study focused on the use of extinction, NCR, and DRO strictly as control (i.e., reversal) conditions and not as therapeutic interventions. Additional factors require consideration when these procedures are used as treatments for problem behavior. As noted previously, the absence of the reinforcer during extinction may have contributed to the efficiency of the procedure. It may be impossible, however, to eliminate the presence of stimuli correlated with reinforcement when extinction is implemented as treatment for problem behavior maintained by attention. In addition, the NCR and DRO conditions used in this investigation were designed such that programmed rates of reinforcement were approximately equal to rates of reinforcement obtained under contingent reinforcement conditions. The effectiveness and efficiency of these procedures might have been enhanced if reinforcement had been delivered according to a denser schedule initially, as in many therapeutic applications of NCR and DRO (e.g., Vollmer et al., 1993).

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STUDY QUESTIONS

1. What are two key features of positive reinforcement contingencies that control procedures must accommodate, and to what extent do extinction, noncontingent reinforcement (NCR), and differential reinforcement of other behavior (DRO) adequately control for these potential sources of influence on behavior?

2. What participant behaviors were recorded in addition to the target responses, and why were data taken on these behaviors?

3. Briefly describe the extinction, NCR, and DRO procedures.

4. What experimental designs were used to compare the procedures, and why were they selected?

5. How did the experimenters ensure that the participants experienced the contingencies associated with each condition?

6. Summarize the results of the study with respect to the effects of extinction, NCR, and DRO on response decrement and recovery.

7. What data suggested the presence of negative side effects?

8. How did the authors determine that the delivery or the mere presence of the reinforcer may have maintained responding during some control conditions?

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